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THE HEAT CAPACITY OF TITANIUM FROM 15° TO 305° K

by

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FOREWORD

This work was carried out at The Ohio State University Cryogenic Laboratory under contract with U.S. Navy, Office of Naval Research Contract Number N6ori-17, Task Order IV, ONR Project Number NR 058 039, with The Ohio State University Research Foundation. This report covers information obtained during the study entitled: "High Temperature Thermodynamics of Inorganic Substances." It represents the 8th Technical Report of this series.

Director - H.L. Johnston

Editor - E.R. Fultz

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ABSTRACT

The heat capacities of titanium have been measured in the temperature range 15° to 305° K, and the derived thermal functions have been calculated and tabulated at integral values of the temperature over this range. The entropy at 298.16° K is 7.33 ± 0.02 e.u.

INTRODUCTION

Low temperature heat capacity measurements on titanium have been made by Kelley[2] between 53° and 295° K, but his sample contained over 1% of impurities. The titanium used in the present research was of much greater purity than Kelley's, and hence the thermal data reported should be more accurate.

APPARATUS AND MATERIALS

The sample of iodide-process titanium was generously donated by the New Jersey Zinc Co., Palmerton, Pa. The principal contaminants were 0.0082% Mn, 0.007% Si, and 0.0066% Al, with a total of 0.02% of N, Te, Pb and Cu. The rough rod was cut into small pieces on a shaper and these pieces were annealed in a high vacuum at 800° C.

"Solid Calorimeter No. 3," one of the group of seven vacuum calorimeters described in the first paper of this series,[1] was used for the heat capacity measurements on 121.656 g (2.5481 g atoms) of titanium.

EXPERIMENTAL RESULTS AND CALCULATIONS

The experimental heat capacity data are presented in Table I. These deviate from a smooth curve by an average 0.2 of 1%. Skinner[3] noticed that his data on zirconium were higher than Todd's data below 130° K and lower than Todd's data above 130° K. The discrepancy was attributed to oxygen in Todd's sample. The present data show a similar discrepancy with Kelley's data, the temperature of intersection of the two heat capacity curves being about 180° K, and again the reason seems to be due to the contaminants in Kelley's titanium.

The heat capacity and derived thermal functions for titanium at integral values of the temperature are presented in Table II. The entropy at 298.16° K is 7.33 ± 0.02 e.u. of

which only 0.13 e.u. was obtained by extrapolation by the Debye T^3 law. This compares with the value 7.24 e.u. obtained by Kelley.[2]

TABLE I

HEAT CAPACITY OF TITANIUM
At Wt = 47.90 g 2.5481 g atoms

Mean T °K	C_p cal/deg/g atom	Mean T °K	C_p cal/deg/g atom
15.44	0.046	94.76	3.252
17.36	.056	104.49	3.583
18.75	.067	114.76	3.887
20.04	.081	127.07	4.215
21.31	.090	137.65	4.439
22.87	.117	148.70	4.654
24.60	.149	160.37	4.855
26.71	.192	172.74	5.020
29.32	.260	185.70	5.161
32.23	.349	198.46	5.305
35.26	.456	212.40	5.427
38.67	.590	215.29	5.466
43.54	.808	224.52	5.536
49.04	1.085	234.03	5.602
53.89	1.350	248.05	5.682
58.00	1.572	259.30	5.768
59.33	1.653	271.73	5.865
63.95	1.873	283.32	5.913
70.27	2.173	293.57	5.950
77.00	2.489	299.58	5.958
85.62	2.880	305.51	6.005

TABLE II

THERMAL FUNCTIONS OF TITANIUM

T, °K	C_p° cal/deg/g atom	S° cal/deg/g atom	$H^\circ - H_o^\circ$ cal/deg/g atom	$-(F^\circ - H_o^\circ)/T$ cal/deg/g atom
15	0.040	0.013	0.15	0.003
25	.157	.054	.94	.017
50	1.136	.414	15.31	.108
75	2.402	1.123	50.1	.322
100	3.434	1.963	133.7	.626
125	4.155	2.811	229.0	.979
150	4.684	3.652	339.9	1.386
175	5.043	4.403	461.9	1.764
200	5.321	5.095	591.5	2.137
225	5.539	5.735	727.3	2.502
250	5.713	6.328	868.0	2.856
275	5.864	6.879	1012.8	3.196
298.16	5.976	7.334	1149.9	3.478

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